Dr. G. Granville Bantock; a Ring-tailed Coati (*Nasua rufa*), a Kinkajou (*Cercoleptes caudivolvulus*) from South America, deposited; an Indian Civet (*Viverricula malaccensis*) from India, a Chilian Sea Eagle (*Geranoaëtus melanoleucus*) from South America, purchased; a Patagonian Cavy (*Dolichotis patachonica*), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

THE DISINTEGRATION OF COMETS.—If a comet is regarded as a swarm of meteorites, *à priori* considerations point to disintegration as its ultimate fate. Schiaparelli and Bredichin have familiarised astronomers with this fact, and the Great Comet of 1882, as well as Brooks' Comet of 1889, were visible examples of the way in which cometary members of the solar system break up in their old age. M. M. O. Callandreau has a short article in the *Bulletin Astronomique* (September) upon this disintegrating tendency, and also upon the relation of Jupiter to comets of short period. The two subjects are very closely related, for there is evidence that individual orbits in the groups of comets of short period in the neighbourhood of Jupiter have been produced by a process of separation. What M. Callandreau has done is to estimate, in a general manner, the influence the trajectory described by the head of a comet has upon disintegration, and to determine the extent of the sphere of stability at different points of the orbit both when the sun's attraction is considered alone, and when it is considered with the action of Jupiter. The subject is dealt with entirely from a dynamical point of view, no account being taken of the influence of thermal radiation from the sun or of the apparent force of repulsion exercised by the sun upon cometary material. A comet is considered as a spherical swarm of particles, and the density of the swarm is either taken as uniform or varying uniformly with distances from the centre. It appears that the elliptical form of an orbit favours disintegration. The following consequences follow from equations obtained by considering the sun's action alone: (1) When the distance of the nucleus remains constant, the extent of the sphere of stability increases with increase of velocity. (2) The relation of the radii of the spheres of stability at aphelion and perihelion is approximately equal to $\left(\frac{1 - e'}{1 + e'}\right)^{\frac{2}{3}}$, where e' is the eccentricity of the orbit. As to the combined influence of the sun and Jupiter, it appears that if a comet gets within the Jovian sphere of attraction, the radius of which is 0·3 the radius of the earth's orbit, the disintegrating power upon the comet when near aphelion is equivalent to that of the sun upon a comet when at a perihelion distance of 0·58.

FORECAST OF THE NOVEMBER METEOR SHOWER.—Mr. W. F. Denning continues, in the *Observatory*, an interesting paper upon "The Great Meteoric Shower of November," and predicts the probable character of the showers which will occur during the next six or seven years. His forecast for this year's display is as follows:—"In 1864 (two years before the max. of 1866), a grand display of meteors was witnessed from the deck of a ship off Malta on the morning of November 13, and meteors were conspicuously numerous on the same morning in America. We are therefore entitled to expect a pretty abundant display in 1897, and should it prove a return of the same group which supplied the meteors of 1864, it will probably return in the morning hours of November 14. But the earth will intersect a point of the meteoric orbit rather further in advance of the comet than it did in 1864, and so the exhibition of 1897 is not likely to equal the former, unless, indeed, the richer part of the stream has lengthened out in the interval of thirty-three years, which is quite possible. The really dense part of the system which furnished the brilliant European display of 1866 (max. Nov. 13, 13h. 10m.), and the equally imposing American shower of 1867 (max. Nov. 13, 22½h.), is not likely to be visible in England, as the earth will be centrally involved with it on the 14th at midday. In America something of it may possibly be seen just before sunrise on the 14th. The moon will be full on the morning of the 9th, and will therefore be gibbous on the 14th, rising at 7h. 55m. at Greenwich, and being visible in Gemini during the whole night afterwards. The prospects are therefore by no means good, but a close watch should be maintained on the mornings of the 14th, 15th, and 16th; for if the atmosphere be clear, meteors will sure to be frequent, and fine ones may appear every now and then."

THE RELATIONSHIP OF PHYSIOLOGY, PHARMACOLOGY, PATHOLOGY, AND PRACTICAL MEDICINE.[1]

THE desire for knowledge which is common to the lower animals and man, savage or civilised, and has induced members of this Congress to come from the ends of the earth in order to gain information, must have led primitive man from the earliest times to study the great problems of physiology, the nature of life, of growth, of reproduction, and of death, as well as to notice the connection of the latter with mechanical injuries, such as the wounds inflicted by clubs and spears or by the teeth and claws of wild beasts.

Next to the problems of physiology come those of pharmacology, by which I mean the poisonous or remedial action of various substances, mineral, vegetable, or animal. A knowledge of this subject is found even amongst the lowest savages, and is of the greatest use to them, for it enables them, on the one hand, to avoid eating things which may cause discomfort, pain, or death, and, on the other, to obtain food by poisoning waters and thus catching fish, or by poisoning their arrows to kill game which would otherwise escape. Closely associated with the knowledge of the poisonous is that of the curative powers of herbs, and it is possessed by animals as well as man, for cows avoid noxious plants, and dogs will every now and again eat grass apparently as medicine. Primitive peoples use various substances as remedies in disease, with more or less success, and one of the most extraordinary points in their practice is that they seem to some extent to have forestalled the newest researches on venins, anti-venins, and organotherapy, for in Africa the Bushmen are accustomed to drink the poison of venomous snakes as a prophylactic against their bite, and the Hausas prevent hydrophodia by killing the mad dog and making the man it has bitten eat its liver.

The occurrence of death from wounds or poison is intelligible even to a savage, but when illness and death occur independently of these, men naturally attribute them to invisible powers. Thus the Dyaks of Borneo ascribe sickness to wounds from invisible spears weilded by invisible spirits, and during an epidemic of disease in the Middle Ages the cry often arose that the wells had been poisoned. These crude ideas contain germs of truth, and when we look at Prof. Metschnikoff's drawings of a Daphnia attacked by a Monospora we seem to recognise the invisible darts of the Dyaks, while during an epidemic of typhoid fever we have often to acknowledge that our wells have been poisoned by bacilli.

It is impossible to trace the steps by which the crude ideas of savage peoples regarding physiology, pharmacology, and pathology have grown into definite sciences, nor even to indicate the most important landmarks, though we naturally think of the names of Alkmaon, Galen, and Harvey in physiology; of Nicander, Magendie, and Bernard in pharmacology; and of Morgagni, Virchow, and Pasteur in pathology. During this century these three sciences have developed with almost incredible rapidity, a complete knowledge of them is enough to tax severely the most retentive memory, and it is almost impossible for any individual to keep up with the advance of all three of them.

But just as the whole subject of astronomy became suddenly simplified by a change of standpoint at the very time when cycles and epi-cycles became most bewildering, so at the very time when these three sciences are becoming most complex and diverse they appear to be tending to unification and simplification. Pathology, for example, is now becoming to a great extent a branch of pharmacology, for while a few years ago its chief object was to discover, examine, and classify the microbes which give rise to disease, it is now striving rather to discover the nature and actions of the ferments and poisons which they form, and by which they are able to cause disease and death in the animals they attack. Pharmacological investigation instead of being confined to the alkaloids and other poisons formed by higher plants has now extended to those formed by microscopic plants or microbes, and thus comes to include a great part of pathology.

In the same way, though pharmacology is a branch of physiology, inasmuch as it deals with the phenomena of life as modified by drugs, yet physiology may, to a certain extent, be regarded as a branch of pharmacology, because some of the latest researches regarding the processes of life have been made by pharmacological methods, using the products of animal life instead of vegetable poisons. Amongst the pioneers in this line I may mention my two masters, Kühne and Ludwig; the former of whom by his chemical investigations has enabled us to differentiate the various products of albuminous decomposition, whilst the latter, with his pupils Schmidt-Mühlheim and Wooldridge, discovered the poisonous action of albumoses and peptones, and of the juices of various tissues when injected directly into the blood.

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[1] An address delivered at the Twelfth International Medical Congress at Moscow, on August 19, by Dr. T. Lauder Brunton, F.R.S.

Before the proteid constituents of our food can be absorbed they must be split up during digestion into albumoses and peptones; yet these researches show that the very substances which are necessary to repair waste and are indispensable for the continuance of life, prove fatal when introduced into the body in a wrong way, or too great quantity. But the products of the digestion of albumin do not normally enter the circulation as albumoses and peptones. During absorption they undergo changes of a synthetic nature in the walls of the intestine, and probably to a certain extent also in the liver, so that they again form harmless substances, and their poisonous properties are destroyed before they enter the general blood stream.

But how is it that the ferments which decompose albuminous food and form poisons from it in the intestine do not pass into the blood and kill the animal by digesting the tissues and forming poisons from them? Of course pepsin cannot do so as it only acts in an acid medium, but there is no such hindrance to the action of trypsin, and yet it does not destroy the tissues composing the body itself. In all probability the reason why digestive ferments do not digest the tissues is not that they are destroyed in the digestive canal, nor yet that they are not absorbed, but that they are altered from active enzymes into inert zymogens which can be stored up without risk, and can again liberate active enzymes when these are required to digest a subsequent meal. In this respect they may be compared to the knives used by wandering peoples to cut up their meat, and which are not thrown away after each meal, but are simply put into sheaths which cover their edges and deprive them for a time of their cutting power.

But it is not in the intestine only that enzymes are found, they are also poured into the blood by the pancreas and probably by the thyroid and other glands. As our acquaintance with the processes of cell life increases, it seems more and more likely that the tissue change on which functional activity depends is effected by enzymes, and the truer do the speculations of Van Helmont appear—that life is a process of fermentation.

There can be little doubt that if enzymes in a free state were to circulate through the body they would do much harm, and indeed we may regard this as well-nigh proved in regard to the enzyme of tetanus.

But their action is limited either by their conversion into zymogens or their localisation to the cells or tissues where their action is required. This is more readily seen in plants than in animals, and one of the best examples of it is that in germinating wheat.

In the ordinary state of the grain the diastatic ferment is kept apart from the starch by a small layer of cellulose, through which the diastase cannot pass, but during germination another ferment appears which has the power of dissolving cellulose, and by breaking down this dividing membrane it allows the diastatic ferment to act upon the starch, and renders it available for the needs of the growing plant.

Enzymes appear to differ amongst themselves nearly as much as do albumin, albumoses and peptones. Some are easily separated from the cells in which they exist, whilst others are so closely united to the protoplasm that their separate existence apart from it has been denied. The yeast plant, for example, yields an invert enzyme which can be extracted with comparative ease, but the enzyme which splits up sugar into alcohol and carbonic acid is so firmly attached to the protoplasm of the cell that it is only within the last few months that it has been isolated by Buchner by the application of enormous pressure. It is probable that the enzymes contained in the cells of animal tissues differ in like manner, and that by the use of similar methods we may obtain a number of enzymes with which we are at present unacquainted.

But it is not merely the products formed in the digestive canal, or in the organs of animals during life, nor even the alkaloids that are formed by the higher plants, that act as poisons. The processes of life are much the same in the lowest microbes as in animals, or in the higher plants, and these microbes, by forming ferments and poisons, give rise to disturbance of function or death in animals. When grown in suitable media outside the body they produce enzymes and poisons, albumoses and alkaloids, and many of them continue to do so after their introduction into the body.

One of the most curious points, both in the chemistry of the higher plants and of microbes, is that they tend to form at the same time a poison and its antidote. In Calabar bean, for example, we find there are two poisons—physostigmine and calabarine, the former tending to paralyse the spinal cord and the latter to stimulate it, so that each poison to a certain extent antagonises the other. The same condition is found even more markedly in jaborandi, of which the two alkaloids pilocarpine and jaborine antagonise one another's action so that, although pilocarpine generally greatly predominates, it might be possible to get a specimen of the leaf having no action at all although it contained a quantity of alkaloids.

When injected into animals the toxins formed by microbes and the venins of serpents cause the production of anti-toxins and anti-venins which neutralise their action apparently by chemical combination in somewhat the same way as an acid and alkali, each poisonous by itself, combine to form a comparatively inert salt. But the two components here, like an organic acid and a mineral base, are unequally affected by destructive agencies, and the anti-venin may be destroyed, so that the venin again regains its activity.

The conversion of zymogens into enzymes may be compared to the freeing of venins from their compounds, while the conversion of active venins into inert bodies by combination with anti-venins suggest that a similar process may occur in the case of active enzymes, by which they may be converted into inactive zymogens.

Perhaps the hypothesis I mentioned eight years ago to my pupil and friend, Mr. Hankin, that the germicidal power of organisms is proportional to their power to produce enzymes may not be altogether unfounded, and possibly we may discover also that immunity, natural or acquired, is nothing more than an extension to the cells of the tissues generally of a power which is constantly exercised during digestion by those of the intestine and liver.

This problem is one which pertains to all three sciences, and has a most important bearing on practical medicine.

Practical medicine, except when empirical, depends for its advance on physiology, pharmacology, and pathology. A knowledge of the physiology of digestion has led to the satisfactory treatment of dyspepsia by the administration of digestive enzymes, and pharmacological research has enabled us to treat diseases of the circulation with a success previously undreamt of, by teaching us not only how to use aright old remedies, such as digitalis, but also how to apply new ones, such as strophanthus and amyl nitrite, and even to manufacture others, such as nitro-erythrol, which possess the special actions we desire, but are lacking in the drugs we already have. Indeed new remedies, which shall alter tissue change, lower temperature, relieve pain, and procure sleep, are now being made in such numbers that it is hard to keep count of them.

But amongst all the new gains of practical medicine none are so remarkable as those which we owe to pathology. Time would fail me to speak of the prevention and cure of zymotic diseases, but no less astonishing is the discovery that myxœdema depends on inactivity or absence of the thyroid gland, and can be cured by the administration of its extract, which seems to act as an enzyme on living tissues, so that the heavy, shapeless features of the patient resume their natural expression, and the sluggish mental processes become quickened. An exhaustive study of enzymes and their products appears to be the most promising way of advancing our knowledge both of the nature and treatment of disease. Probably more is to be hoped for from an investigation into the nature and properties of those enzymes which are intimately associated with the protoplasm of the cells in the various tissues and organs than even of those which are poured into the blood by glands having an internal secretion, such as the thyroid. For all organs, even those which like muscles and nerves are not glandular, have an action on the blood comparable to that of the yeast plant, which modifies the fluid in which it lives by the substances which it removes from or adds to it. It is to a knowledge of the processes which occur in the protoplasm of the cells in the intestinal wall and liver, and of the enzymes by which these processes are in all probability carried out that we must look for an explanation of the conversion of the poisonous albumoses formed during digestion into innocuous albumins, and of dangerous enzymes into harmless zymogens.

Moreover, it seems to me that it is by researches into the nature and action of the enzymes not only of microbes, but in the various tissues of the body in higher animals, that we shall learn how the microbes, like the enzymes of the intestinal canal, produce poisonous albumoses, and how the tissues, like the cells of the intestinal walls or liver, convert them into harmless or even protective substances. In this way we may hope to obtain an explanation of toxins and anti-toxins, of pathogenesis and immunity, as well as of the nature of diseases unconnected with the presence of microbes, such as diabetes. Twenty-three years ago I attempted to obtain a glycolytic enzyme from muscle, in order to enable diabetic patients to utilise the sugar in their blood. My attempt was unsuccessful, but we may still hope that by other methods we may obtain from animal organs various enzymes, the administration of which may prove as useful in other diseases as the thyroid in myxœdema.

Practical medicine depends on physiology, pharmacology, and pathology, but all three are tending to become more and more subdivisions of the wider and all-embracing science of chemistry. It is to a chemist, Pasteur, that we owe the wonderful development of pathology within the last quarter of a century, and we may fairly regard his fellow-countryman, Lavoisier, as the founder of this science. Men from all countries, and especially from Germany, have aided its development; but it seems fitting that at this Congress, in acknowledging our obligations to this science, we should not omit to mention that at its head now stands a Russian, Mendeleef, whose marvellous prescience enabled him to predict the existence of elements which were then unknown and even to describe their properties more correctly than those who first verified his predictions by obtaining the substances themselves. When we consider that little more than a hundred years have elapsed since the time of Lavoisier, and contemplate the vast benefits which medicine and its allied sciences have derived from chemistry during this time, our hopes cannot be otherwise than great for the centuries to come.

THE BRITISH ASSOCIATION.

Toronto, *August* 25.

THIS has not been a large, but it has been a very interesting and satisfactory meeting both from the scientific and the social point of view. Out of the 1362 persons present, an unusually large proportion were well-known representative men of science. The more prominent members of each section seem to be with us, and it has been frequently remarked during the meeting that in our sectional officers we have brought over an unusually strong team. We have a fair number of distinguished foreigners, and a considerable number of the members of the American Association: these foreign members include General Billings, Dr. Anton Dohrn of Naples, Profs. Minot, Newcomb, Osborn, Putnam, Ira Remsen, Runge (Hannover), and others. Many Canadians have also taken part in the proceedings, and it may be said that in all the sections the work has been influenced in its nature and direction by our place of meeting. Canadian surveys, geography and climate, the chemistry of the soil, the fisheries and the biology of the lakes, the plants, the timber from the engineering point of view, statistics and trade combinations all received attention; while Sections C (Geology) and H (Anthropology) may fairly be said to have been dominated by the local spirit. The president of C was a distinguished Canadian geologist, Dr. George Dawson, and although the preliminary arrangements had to be made in this case by correspondence, the work of the section was remarkably well organised, and an unusually large number of abstracts were printed. There were papers and demonstrations on the rocks of North America from the Laurentian to the Glacial deposits, and several expeditions of geological interest were organised under local leaders. The Anthropological Section had a succession of interesting papers—notably those of Miss Alice Fletcher—dealing with the folk-lore, customs, religion, &c., of the North American Indians. The work of these two sections appropriately culminated to-day in a joint discussion on "The First Traces of Man in North America," during which Prof. Putnam gave an account of the supposed remains from the Trenton gravels. Prof. Claypole spoke of the human relics in the Drift of Ohio, and Sir John Evans criticised the evidence adversely and showed the probability of error as to the occurrence of the specimens supposed to be from glacial deposits.

Amongst other notable papers which attracted public attention were Profs. Meslans, Moissan and Dewar's demonstration of the preparation and properties of fluorine, and Lord Kelvin's statement as to the fuel supply and air supply of the world.

There seemed to be comparatively few joint meetings of sections—perhaps because each section was so full of its own work. Besides the combined session of C and H, mentioned above, E and F met to hear Mr. F. C. Selous on the economic geography of Rhodesia, and sections C, I, and K joined in discussing the chemistry and structure of the cell *à propos* of Prof. Meldola's paper on the rationale of chemical synthesis, Prof. Green's paper on an alcohol-producing enzyme in yeast, Prof. Macallum's paper on the significance of intracellular structures, and some histo-chemical demonstrations by Profs. Boyce and Herdman on the presence of copper, and by Prof. Macallum on the distribution of iron, in tissue cells.

The custom seems increasing in most of the sections of having a certain number of short addresses, lecturettes, or demonstrations on subjects of novelty or current scientific interest given at fixed times, and usually illustrated by lantern slides. Amongst these at the present meeting may be mentioned:—Sir George Robertson on Kafiristan, Prof. Dixon on explosion flames, Prof. Osborn on American Tertiary mammals, Dr. Munro on the Glastonbury Lake Village, Prof. Herdman on the oyster question, Prof. Poulton on mimicry and natural selection, Prof. Haddon on the evolution of the cart and the Irish car, and Mr. Seward's address on fossil plants. Section K had also some interesting papers and discussions on hybridisation, including an account by Dr. W. Saunders, Director of the Dominion Experimental Farms, of some experiments in cross-fertilisation made with the practical object of producing improved forms of apple and other fruit trees which will stand the severe climate of the North-west Territories. As an outcome of our visits to the experimental farms, and of what we have heard of them, both in the sections and outside, an important resolution, forwarded from Section B (Chemistry), has passed the Committee of Recommendations and the General Committee, to the effect that "the Council be requested to consider the desirability of approaching the Government with the view of the establishment in Britain of experimental agricultural stations similar in character to those which are producing such satisfactory results in Canada."

It may also be stated that, as the result of the consideration given by Section D to the fauna of the lakes, it is expected that a biological station will shortly be established by the Government of Ontario. A deputation of zoologists with this object in view waited upon the Premier and other members of the Cabinet, and the proposition was very favourably received. A fuller account of this matter will be given in the report of the proceedings of Section D.

Several of the sections, recognising that we are meeting in a new country, the natural products of which are more or less unfamiliar to many of the members, organised afternoon and even whole-day excursions in the neighbourhood of Toronto, under the guidance of local leaders. In this way Section B visited the chemical works at Niagara, Section C the glacial deposits, while Sections D and K had several joint expeditions to localities of biological interest. The General Committee at its final meeting to-day passed the report of the Committee of Recommendations recommending grants to committees for scientific purposes amounting to 1350*l.*, a much larger sum than has been voted for some years. One of the reasons of this increase is that the committee are extremely anxious to make some grants for the pursuit of local investigations, to be expended by the various committees which have been appointed for the purpose of study and research in Canada. These Canadian committees are appointed for the following objects: the establishment of a meteorological observatory on Mount Royal, the investigation of the pleistocene fauna and flora, the collection of geological photographs, the biology of the lakes of Ontario, the condition of the North-west tribes, the ethnographic survey of Canada, and the establishment of a biological station in the Gulf of St. Lawrence. The total amounts voted to Committees are shown on the next page.